SUSTAINABILITY IN WASTEWATER TREATMENT

Ref.:

Ødegaard, H.: "An evaluation of cost efficiency and sustainability of different wastewater treatment processes". VATTEN 51:291-299, Lund 1995

Often "sustainable wastewater treatment" is used in connection with nature-based treatment technologies - as ponds, reed-beds, infiltration systems, constr. wetlands etc
Is the term used that way to distance nature-based treatment from the conventional one ?

The processes are the same in conventional and nature-based systems, but we may differentiate byusing the term conventional for systems :

- that take place in enclosed reactors
- that speed up the processes by added resources (air, chemicals, energy etc)

Conventional systems are more space efficient and can be used for any size of plants while nature-based systems are limited to smaller plants (2000 pe)

Wastewater treatment plants consumes :

- Materials (concrete, steel, plastics etc)
- Chemicals (coagulants, flocculants, disinfetants etc)
- Energy (electricity, heat etc)
- Land (for the plant itself, for sludge disposal etc)

and produce :

- Clean(er) water containing heat and nutrients
- Sludge containing several resources
  - Energy potential (biogas, fuel etc)
  - Chemicals that can be recycled
  - Nutrients (phosphate) that may be recycled)

To me
sustainable wastewater treatment means
treatment that consumes as little :

- materials
- chemicals
- energy
- land

as possible and make reuse of the water, the nutrients, the energy and the chemicals

This means that it is meaningless to say that nature-based systems are more sustainable than conventional or that small or on-site systems are more sustainable than centralised systems.

It all depends on local circumstances

In Mexico City, for instance, the wastewater is a resource that has to be utilised (water for irrigation and replenishment of the groundwater level, nutrients for fertilising crops). This can only be done through careful handling of waste-water in a centralised system

Standard conventional treatment
(e.g. a low loaded activated sludge plant)
is not particularly sustainable because :

- it uses a lot of materials (concrete)
- it uses a lot of energy (for aeration)
- it converts most of the organic matter to useless CO_2
- it does not optimally take care of the nutrients of the wastewater

Benefits by the use of biofilm processes instead of activated sludge processes

- Higher active biomass per unit volume of reactor
- More specialised biomass (less mixture of bacteria) in the location of the plant where you want it
- Sludge concentration in biofilm reactor outlet far lower than in activated sludge reactors
- Biofilm reactor independent of sludge separation reactor downstream - no recirculation
- Far more compact solutions - less land and less energy for heating

Is the use of chemicals sustainable ?

- It is often claimed that biological treatment methods are more sustainable than physical/chemical methods.
- It was therefore decided to try to evaluate this by comparing processes that included chemical pre-treatment with process solutions primarily based on biological processes - with respect to cost and energy "from craddle to grave". The cost and energy use was related to the effect in the receiving water through the oxygen consumption potential concept
- Several flow schemes of a 100.000 pe plant was evaluated
- Both fresh water and marine water was evaluated - only fresh receiving water will be discussed here

The simpel basis for the calculations of the oxygen consumption potential (OCP)

- 1 kg of BOD gives max 1 kg in primary oxygen consumption because of heterotrophic oxidation
- 1 kg tot N gives max 4 kg primary OC because of NH_4-N because of autotrophic oxidation of ammonia
- 1 kg tot P gives max 100 kg of secondary OC (algae degrad.)
- 1kg tot N gives max 14 kg of secondary OC (algae degrad.)

Not all the nutrients will lead to algal growth - for simplicity we shall assume that 50 % of the nutrients does

Cost/benefit analyses for different methods

Treatment alternative	Specific cost (NOK/m^3)	Spec. cost per $OCP_{removed}$ (NOK/kg $OC_{rem.}$)
PRIMARY		
Primary settling	1,00	10,52
SECONDARY		
Chemical (Primary precipitation)	1,49	3,88
Biological (High load - activ. sludge)	1,70	7,42
TERTIARY		
Pre-precipitation	1,97	4,79
Simultaneous precipitation	2,06	5,19
ADVANCED TERTIARY (N-REMOVAL)		
Pre-precipitation/post-denitrification	2,85	5,49
Pre-denitrification/simult. precipitation	3,00	5,78
Pre-denitrification/biological P-removal	2,90	5,74

Specific energy required for different methods

Treatment alternative	Specific energy consumption, Wh/m^3_{flow}				
	Chemi-cals	Air	Biogas-el	Tran-sport	Bal ance
PRIMARY					
Primary settling	0	0	+ 85	- 7	+77
SECONDARY					
Chemical (Primary precipitation)	- 30	0	+170	- 15	+125
Biological (High load - activ. sludge)	0	- 158	+170	- 12	0
TERTIARY					
Pre-precipitation	- 30	- 40	+ 200	- 18	+112
Simultaneous precipitation	- 20	- 110	+ 170	- 15	+25
ADVANCED TERTIARY (N-REMOVAL)					
Pre-precipitation/post-denitrification	- 30- 60[1]	- 150	+ 210	- 19	- 49
Pre-denitrification/simult. precipitation	- 20	- 218	+ 120	- 15	- 133
Pre-denitrification/biological P-removal	- 8	- 213	+ 115	- 13	- 118

[1] Methanol

Energy/benefit evaluation for different methods

Treatment alternative	Total energy balance per $OCP_{removed}$ ($kWh/ton\ O_{2,\ removed}$)	
	Incl. energy from biogas	Excl. energy from biogas
PRIMARY		
Primary settling	810	- 74
SECONDARY		
Chemical (Primary precipitation)	325	- 117
Biological (High load - activ. sludge)	0	- 742
TERTIARY		
Pre-precipitation	- 42	- 379
Simultaneous precipitation	- 345	- 635
ADVANCED TERTIARY (N-REMOVAL)		
Pre-precipitation/post-denitrification	- 94	- 499
Pre-denitrification/simult. precipitation	- 256	- 487
Pre-denitrification/biological P-removal	- 234	- 463

CONCLUSIONS

- Sustainable wastewater treatment is treatment that consumes as little materials, chemicals, energy and land as possible

- A flow scheme where a major part of the organic matter is removed "unspoiled" by enhanced particle separation and where energy (biogas) is produced from that concentrate, and utilisation of the other resources in that sludge, combined with a compact (biofilm) process for removal of solubles, seem to come closest to being most sustainable

- The most sustainable single treatment method seems to be enhanced primary treatment (> 80-90 % SS-removal)